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# Designing to Leverage Presence in VR Rhythm Games

**Robert Dongas * and Kazjon Grace**

School of Architecture, Design and Planning, University of Sydney, Camperdown, NSW 2006, Australia
* Correspondence: robert.dongas@sydney.edu.au

**Abstract:** Rhythm games are known for their engaging gameplay and have gained renewed popularity with the adoption of virtual reality (VR) technology. While VR rhythm games have achieved commercial success, there is a lack of research on how and why they are engaging, and the connection between that engagement and immersion or presence. This study aims to understand how the design of two popular VR rhythm games, Beat Saber and Ragnarock, leverages presence to immerse players. Through a mixed-methods approach, utilising the Multimodal Presence Scale and a thematic analysis of open-ended questions, we discovered four mentalities which characterise user experiences: action, game, story and musical. We discuss how these mentalities can mediate presence and immersion, suggesting considerations for how designers can leverage this mapping for similar or related games.

**Keywords:** virtual reality; presence; immersion; rhythm games; user experience; design



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## 1. Introduction

Virtual reality (VR) technology provides a significantly altered mode of interaction with games and entertainment experiences. In recent years, both production and adoption of this technology has increased, providing more opportunities for consumers to enter the novel environments afforded by VR. This broader adoption provides an opportunity to assess how, in real-world contexts, VR achieves its purported aim of being "more immersive", how that immersion affects users' experiences, and how it might be optimised through design. By "immersion" we mean not only the technical capacity of VR systems to occupy more of the visual field, but also the ability of the game to capture the user's attention and engage their senses.

One popular genre that has shown great potential for VR is rhythm games, which are known for their engaging and interactive gameplay [1]. While rhythm games have been part of the gaming industry for many years, VR has provided a resurgence in popularity, as evidenced by high downloads and ratings [2]. They are typically viewed as highly immersive, offering players a unique and captivating experience. Many VR rhythm games incorporate an "exergame" component (i.e., physical movement of sufficient intensity as to approximate aerobic exercise), indicated by their categorisation as "Workout" or "Sports" games on popular application stores (not just "Rhythm" or "Music" games). The potential cognitive and physical benefits make them even more appealing, suggesting the efficacy of VR rhythm games for encouraging exercise [3]. Despite these games' commercial success and the burgeoning academic research on their exercise capabilities, little research has been done to investigate how and why they are so engaging, nor the connection between that engagement and immersion or presence. That research deficit applies both to VR exergames in particular as well as VR rhythm games more broadly.

In this study we take a design research perspective, seeking to understand, through mixed qualitative and quantitative analysis, how two popular VR rhythm games leverage presence and immersion to engage their players. From this analysis we generalise a way of thinking about presence and immersion that has the potential to be useful to the designers of comparable VR experiences. While they are often conflated, it is important to note that there are conceptual differences between presence and immersion (see Sections 2.1 and 2.2). In

this research we acknowledge the two phenomena as separate, in an attempt to understand how user experiences relate to both.

Through building a data-driven interpretation of users' experiences in two popular VR rhythm games, we propose how designers can maximise the affordances of particular kinds of presence and immersion in their virtual worlds. We conducted an empirical study to compare experiences of presence and immersion in two different games: Beat Saber and Ragnarock. The study employed a mixed-methods approach, utilising a convergent approach to combine quantitative and qualitative data [4]. The quantitative data was collected using the multi-modal presence scale [5], which measured users levels of presence, based on Lee's [6] model of presence (physical, social and self). The qualitative data was gathered through open-ended questions and analysed using thematic analysis [7], to identify and categorise patterns in the data. The results of the quantitative and qualitative analyses were integrated to synthesise a set of "mentalities" that users adopted, each of which impacts both their sense of presence and their immersion in the game.

We present an analysis of how the design features of these two games afford different user mentalities, and how these mentalities in turn mediate experience to differently immerse players. We argue that Beat Saber and Ragnarock's designers have each achieved high levels of both presence and immersion by targeting very different user mentalities. Through this we demonstrate a potential pathway for designers to evoke the different kinds of presence [6,8,9] and immersion [10–13] that have been explored in the literature by constructing experiences that afford user mentalities. We believe (although have not validated) that these mentalities may be accessible and effective targets for game designers thinking about the experiences they hope to create. We conclude by proposing several design considerations around this idea of mentalities that mediate this presence-immersion mapping, allowing designers to to emphasise particular components of both.

## 2. Background

### *2.1. Presence*

Presence, or the feeling of being present in a virtual environment, is a concept that has been studied extensively, including in psychology, media studies, and game design. Despite its widespread attention, presence is still a debated concept with a variety of definitions and associated theories [14]. There are also debates around how presence can be measured consistently and accurately. For example, different people may experience presence differently and to varying degrees, making it challenging to generalise findings across different populations [15]. Even after a definition of presence has been adopted, the conditions that contribute to presence are ephemeral and contextual, varying based on the virtual environment, the type of task being performed, and the individual's characteristics and prior experiences.

Biocca's theory of presence posits that presence is a multidimensional construct that is influenced by various factors [16]. According to Biocca's theory, presence is comprised of three subdimensions: physical, social, and self. Physical presence refers to the degree to which the player feels physically present in the virtual environment, including the sensation of being able to touch and interact with virtual objects. Social presence refers to the extent to which the player feels connected to other people or avatars in the virtual environment. Self presence refers to the degree to which the player perceives their body (including visually, physically and emotionally). These dimensions work within a three-pole model, fluctuating between the physical (real) environment, remote (virtual) environment and imaginative (mental) environment. While this theory was influential in advancing the understanding of presence as a multidimensional construct, it did not explicitly specify a measurement instrument for assessing presence.

Lee's theory of presence is a model for understanding how individuals experience a sense of being present in mediated environments, including virtual reality [6]. The model uses the same dimensions as Biocca (physical, social and self), but differs in the way these are distinguished from each other. In Lee's model, presence is defined as a "psychological

state" where physical objects, social actors and the self/selves are all experienced to some degree in "sensory or nonsensory ways". This contrasts with Biocca, who formulates presence as the "perceptual sensation of being in a place other than where your physical body is located" [16]. Lee's model expands on all three sub-dimensions to encompass additional technological mediums, simulated social interactions or alternative constructions of self-identity. Simultaneously, it draws distinct boundaries between each component, addressing limitations in previous typologies. We believe this provides a suitable contextual framing for understanding the concept of presence, which can be utilised in the application of VR rhythm games, but also more broadly in different immersive contexts.

The Multimodal Presence Scale (MPS) is a presence measurement instrument based on Lee's theory of presence [5]. The MPS consists of three sub-scales, each corresponding to one of the three identified dimensions of presence. The physical presence sub-scale measures aspects like physical realism, captivation and a sense of being in the virtual environment. The social presence sub-scale assesses the extent to which users feel connected with social actors in the environment, including their awareness, understanding, and interaction with these actors. The self presence sub-scale covers the degree to which users feel as if they are embodied in the virtual or mediated environment, and the relation of this embodiment to the users' self-identity. Each sub-scale consists of a series of statements that users are asked to rate on a 5-point Likert scale. While still relatively new, the MPS is a well validated and reliable instrument based on Confirmatory Factor Analysis and Item Response Theory [5].

Subsequent additional theories of presence have further clarified typologies or attempted to unify the concept [17]. While we utilise Lee's theory of presence as our foundation, with the MPS used in conjunction, we acknowledge the contributions of newer models. One of these contributions is Slater's [8] theory of Place Illusion and Plausibility Illusion. In this theory, Place Illusion is referring to the sense of 'being there' in a virtual environment, while Plausibility Illusion relies on believing that the events occurring in the virtual environment are real or could potentially happen in the real world. Together these orthogonal illusions (which are not explicitly separated in Lee's theory) contribute to the overall feeling of presence, which is particularly relevant in the context of immersive virtual systems such as VR.

The evolutionary model of presence proposed by [9] suggests that the feeling of presence arises from a combination of cognitive and affective processes that are activated when an individual interacts with a virtual environment. These processes include intention, action, and engagement, which work together in layers to create a sense of being present in the virtual environment. This is particularly interesting for VR rhythm games, with music being interpreted and responded to both cognitively and affectively [18]. The model also proposes that "maximal presence in a mediated experience arises from an optimal combination of form and content, able to support the intentions of the user." While this model has led to the development of the Flow for Presence Questionnaire [19], it has not seen the same level of validation and adoption as the MPS. See [20] for a review on other measures based on alternative theories.

### *2.2. Immersion*

Like presence, immersion is a term with a complex background that has been defined in different ways by researchers from a variety of fields [21]. In the context of VR, some researchers view immersion as an objective property of technology, based on the "extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses" [22]. Others posit immersion is a "psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" [23].

These different types of immersion can be separated into two broad categories: perceptual and psychological [10]. Perceptual immersion refers to the extent to which a technology is able to immerse its user in a virtual environment. This can be influenced by factors such as the quality of the visual and auditory stimuli, the level of realism of the virtual

environment, and the degree to which the technology is able to respond to the user's movements and actions. Psychological immersion refers to the extent to which the user is able to engage with the content being presented in the virtual environment. This may be impacted by things like the believability of the story, the level of interactivity and agency afforded to the user, and the specific task requirements of the experience.

Despite often being used interchangeably in mainstream discourse about games, there are important distinctions between presence and immersion [24]. Notably, presence is a "pre-reflexive" sensation [25], where immersion is a "cognitive state of involvement" [12]. Reference [13] argues that immersion is dependent on audiovisuals, atmosphere and plot, and achieved through increasing levels of involvement, namely: engagement, engrossment and total immersion. Given the intersection between VR and game studies in our research, we adopt a holistic perspective of immersion based on the above theories, acknowledging the experiential complexities of the phenomenon [26].

Mäyrä and Ermi's SCI model of immersion describes three different types of immersion that can be experienced while playing games: sensory, challenge-based, and imaginative [27]. Sensory immersion refers to the sense of being physically enveloped in the game world, achieved through high-quality graphics and sound design. Challenge-based immersion occurs when a player is fully engaged in the challenges presented by the game, and is driven by a sense of accomplishment and progress. Imaginative immersion is the feeling of being transported to a different world, and is achieved through a well-crafted game narrative. This is a useful model, although some critiques have been made of the focus on media form [11] and the vagueness of 'imaginative' immersion [28].

In [11], Nilsson and colleagues review the SCI model (amongst others), addressing the limitations mentioned above. Their revision divides immersion into three categories with similar names, yet different definitions: system immersion, narrative immersion and challenge-based immersion. System immersion, based on Slater's definition [29], refers to not only being surrounded by the media form, but also its ability to accurately replicate perceptual activation in the user. Challenge-based immersion is expanded to consider both sensorimotor and cognitive challenges. Narrative immersion encompasses the user's "preoccupation with the story, the diegetic space, and the characters inhabiting this space". Reference [11] examines their proposed taxonomy of immersion through the perspective of different theories of presence. For example, they explore how Place Illusion is primarily connected to system immersion, but could also influence narrative immersion as well. Due to its grounding in theories of presence, we find this to be the most relevant model of immersion for our research.

### 2.3. Rhythm Games

Rhythm games are a genre of video games in which the player must follow a series of predetermined patterns corresponding with music, using specific input methods [30]. Rhythm games often feature a variety of musical styles, and can be played on a variety of platforms, including consoles, mobile devices and arcade machines [31]. In VR rhythm games, players often use motion controllers to mimic the actions depicted on the screen, such as strumming a guitar or drumming on a virtual drum set. Some games also incorporate elements of rhythm-based puzzle solving or challenges that require players to use their body to follow the rhythm in creative ways. Many of these games have received critical acclaim in the decades since their emergence into the gaming mainstream, often with explicit mention of their being engaging and/or immersive. We posit that the connection between bodily movement, playing music, and concurrently listening to it offers a unique kind of environment for immersive experiences, and this study is designed in part to delve into the specifics of that kind of experience.

Many VR rhythm games also fall into the category of 'exergames', incorporating physical activity or exercise into the gameplay experience [32]. VR rhythm exergames often involve dancing, boxing, or other forms of physical activity that require the player to follow the rhythm and execute specific movements. Faric and colleagues found in a qualitative

review that "music was a popular choice to increase fun, immersion, and enjoyment of VR exergames." [1]. Beyond health benefits, rhythm games have been purported to improve motor skills and provide cognitive benefits as well [33,34]. While not the specific focus of our research, it is evident these types of games stand to provide physical benefits to players [35]. We hope to understand how the design elements of these games contribute to presence and immersion, which seems to be a driving factor of why players engage with them for both exercise and entertainment.

## 3. Method

The primary aim of this study was to explore the design of VR rhythm games and understand how the user experience (UX) differs between games. Quantitatively, we measured the users' reported sensation of presence. Qualitatively, we conducted a more general investigation of UX, to examine how design decisions can lead to different constructions of presence for more engaging and immersive experiences. To achieve these aims, we conducted a within-subjects study with 21 participants, comparing their experiences in two VR rhythm games: Beat Saber and Ragnarock (see Figure 1). We were not comparing the games to determine which was 'better' or 'worse'. Both titles are successful rhythm games, indicated by their popularity, positive reviews and commercial success. Rather, we are attempting to draw insights by evaluating how users interact with these games, to establish design considerations for similar future games.


**Figure 1.** Screenshots of the two games used in this study. Top: Beat Saber—using laser swords to slice blocks in time with music. Bottom: Ragnarock—using hammers to hit drums in time with music.

Our assumption was that the design elements of VR rhythm games have a meaningful impact on players' experiences, consequently impacting their feelings of presence and immersion. We expected that these design elements would vary depending on the goals and intentions of the creators, who may prioritise different aspects of the game design in order to achieve specific effects. Specifically, we established the following hypotheses for the quantitative component of this study:

**Hypothesis 1 ($H_1$).** *Physical Presence will be higher for Beat Saber than Ragnarock.*

**Hypothesis 2 ($H_2$).** *Social Presence will be higher for Ragnarock than Beat Saber.*

**Hypothesis 3 ($H_3$).** *Self Presence will be higher for Beat Saber than Ragnarock.*

### *3.1. Procedures*

The study involved 21 participants who were recruited from an interaction design class. Their ages ranged from 18–30 years old. Groups of 3–4 participants completed the study individually but in parallel on different (identical) devices, with each group taking approximately 30 min. Surveys were then completed individually.

Before the study, the participants were informed of the study purpose and asked for their consent, then given instructions about the procedures and each game. The games were played using Oculus Quest 2 headsets, calibrated individually for each participant. They were also given a brief tutorial on how to use the headsets and controllers. Participants were reminded that if they experienced any discomfort or sickness during the study, they should stop playing immediately, remove the VR headset and alert the researcher. No players mentioned experiencing VR sickness or requested to stop before completing the full study.

Participants were asked to play 3 songs of their choice in each game, with a total playtime of approximately 10 min per game. A verbal walkthrough was provided for each game, with the opportunity given to complete the tutorial before starting the experiment if they needed additional information to understand the mechanics (which fewer than 10% of participants opted to do, as the mechanics for both games are relatively self-explanatory). Players were started on the easiest difficulty level, but given given the option to increase the difficulty if they felt it was not challenging enough (which less than 25% of participants chose to do, mostly after completing their first song). The decision to allow players to vary their song choices, tutorial completion, and difficulty level was made to allow them to self-select for engaging and challenging content: music tastes and VR experience levels vary widely, and fixing the content would have guaranteed a less-enjoyable experience for many players. Our experimental design choice was that allowing players to choose their three songs and difficulty levels would let the highest number of players experience content best fit to them, and that this was a good tradeoff against the additional noise it may introduce. After playing each game, participants spent approximately 10 min completing a MPS questionnaire [5] (see Table 1), and three open-ended questions about their experiences of presence in the games:

- What was the main objective you were trying to achieve in the virtual environment?
- Were there any times you felt frustrated? If yes, please describe why you felt that way.
- What did you think about the user interface for [game].

The participants then repeated the process for the second game. To control for potential ordering effects, we alternated the order in which participants played the two games.

**Table 1.** All the statements in the Multimodal Presence Scale, organised by subscales for physical, social and self presence. After [5].

| | **Physical Presence** |
|---|---|
| Statement 1 | The virtual environment seemed real to me. |
| Statement 2 | I had a sense of acting in the virtual environment, rather than operating something from outside. |
| Statement 3 | My experience in the virtual environment seemed consistent with my experiences in the real world. |
| Statement 4 | While I was in the virtual environment, I had a sense of "being there". |
| Statement 5 | I was completely captivated by the virtual world. |
| | **Social Presence** |
| Statement 6 | I felt like I was in the presence of another person in the virtual environment. |
| Statement 7 | I felt that the people in the virtual environment were aware of my presence. |
| Statement 8 | The people in the virtual environment appeared to be sentient (conscious and alive) to me. |
| Statement 9 | During the simulation there were times where the computer interface seemed to disappear, and I felt like I was working directly with another person. |
| Statement 10 | I had a sense that I was interacting with other people in the virtual environment, rather than a computer simulation. |
| | **Self Presence** |
| Statement 11 | I felt like my virtual embodiment was an extension of my real body within the virtual environment. |
| Statement 12 | When something happened to my virtual embodiment, it felt like it was happening to my real body. |
| Statement 13 | I felt like my real arm was projected into the virtual environment through my virtual embodiment. |
| Statement 14 | I felt like my real hand was inside of the virtual environment. |
| Statement 15 | During the simulation, I felt like my virtual embodiment and my real body became one and the same. |

### *3.2. Analysis*

The data collected from the presence scale and open-ended questions was analysed using both quantitative and qualitative methods.

The quantitative data was first analysed using descriptive statistics to summarise the scores for the MPS and compare the ratings between the two games. Due to the small sample size, we tested for normality using the Shapiro-Wilk test, finding that the three subscales were sufficiently normal, but individual questions were not. We were thus able to use a paired-samples T-test (which requires normal data) to determine if there were statistically significant differences between the mean subscale scores for each game. This involved summing the ratings for each subscale item in the MPS, used as overall measures for physical, social and self-presence. At the individual item level within the MPS we instead used the non-parametric Wilcoxon signed-rank test (which has lower statistical power but does not assume normal data) to compare ratings.

The qualitative data was analysed using thematic analysis, which identified common themes and patterns in the responses to the open-ended questions. These questions were designed to elicit participants' feelings about presence and immersion without explicitly mentioning these concepts and potentially influencing their responses. We conducted the thematic analysis for each of the open-ended questions individually, before organising the generated themes across the whole data set.

The thematic analysis was conducted using a systematic methodology [7], with the responses coded and organised based on the content of the data. The themes were then synthesised and integrated with the findings of the quantitative analysis to provide a comprehensive view of the factors that influence presence in VR rhythm games. We used an inductive approach to thematic analysis, which is appropriate for this type of design context as it minimises any pre-existing assumptions or theories being applied to the data.

This allowed us to discover and explore new insights and connections in the data, providing a rich and nuanced understanding of players' experiences of presence in the games.

## 4. Results

The results of our study showed that there were some significant differences in the experience of presence between the two VR rhythm games we compared (Beat Saber and Ragnarock). We used the Multimodal Presence Scale (MPS) [5] to measure participants' experiences of presence in the games (which includes sub-scales for physical, social, and self-presence). In addition, we present the results of our thematic analysis of open-ended responses from participants, identifying common themes and mentalities that influenced their experiences in the games.

### *4.1. Presence Ratings*

Our analysis of the quantitative data showed that both games scored very highly on the physical and self presence scales, as can be seen in Tables 2 and 3. Physical presence was significantly higher in Beat Saber. Social presence was higher in Ragnarock, although not significantly so. The physical and self presence ratings were high for both games, while social was lower.

**Table 2.** Descriptive statistics for our survey on each of subscales in the Multimodal Presence Scale (out of a total of 25). This shows very high results for physical and self presence in both titles.

| | **Beat Saber** | | **Ragnarock** | |
|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** |
| **Physical** | 22.9 | 2.4 | 20.8 | 4.1 |
| **Social** | 13.5 | 5.7 | 16.1 | 5.5 |
| **Self** | 22.0 | 3.2 | 20.9 | 4.0 |

**Table 3.** Between-game paired sample T-test results for each subscale in the Multimodal Presence Scale (out of a total of 25). Beat Saber scored significantly higher in the Physical sub-scale (see Section 4.1.1).

| | ***p*-Value** | **t** |
|---|---|---|
| **Between-game, Physical scale** | 0.0353 * | −2.2574 |
| **Between-game, Social scale** | 0.0721 | 1.8989 |
| **Between-game, Self scale** | 0.2976 | −1.0696 |

* Statistically significant at $p < 0.05$.

#### 4.1.1. Physical Presence

Overall the level of physical presence was higher for Beat Saber than for Ragnarock, supporting $H_1$. This was calculated using the summed ratings of the first 5 statements of the MPS questionnaire. We first performed the Shapiro-Wilk test to confirm normality ($W = 0.9638$, $p = 0.6220$). Results of a paired-sample t-test indicated that there is a significant difference between Beat Saber ($M = 22.9$, $SD = 2.5$) and Ragnarock ($M = 20.8$, $SD = 4.1$), $t = 2.3$, $p = 0.0353$.

For the individual statements of the physical presence subscale, there were no statistically significant differences (potentially due to the reduced power of the Wilcoxon signed-rank test). The means are most different for items 1 ("seemed real", Beat Saber: $M = 4.4$, $SD = 0.7$; Ragnarock: $M = 4.0$, $SD = 1.0$) and 4 ("being there", Beat Saber: $M = 4.9$, $SD = 0.4$; Ragnarock: $M = 4.3$, $SD = 1.1$), suggesting these items influenced the significant difference for the overall physical presence subscale.

These results indicate that Beat Saber generated a higher degree of physical presence within the virtual environment. This could be due to a feeling of a more 'real' environment and a greater feeling of 'being there', based on the ratings for statements 1 and 4 of the MPS. Despite the differences, ratings were high for both games, skewing towards 'agree' and 'strongly agree' (see Figure 2). This suggests that both games are able to create a sense of physical presence for players, although the design of Beat Saber may be slightly more effective in this regard.

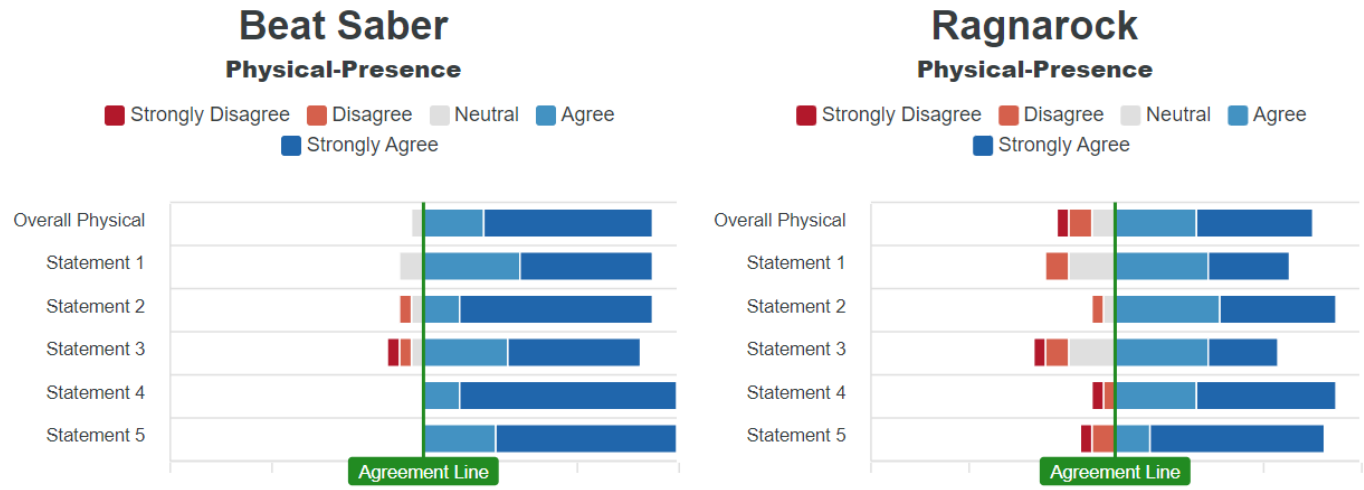


**Figure 2.** Comparison between physical presence ratings for Beat Saber and Ragnarock. This shows very high results for physical presence in both titles. Additionally, Beat Saber scored significantly higher in the overall Physical sub-scale, as well as statements 1 ("The virtual environment seemed real to me") and 4 ("While I was in the virtual environment, I had a sense of 'being there'").

#### 4.1.2. Social Presence

For the overall social presence sub-scale, a Shapiro-Wilk test again supported normality (W = 0.9724, 0.8040). On a paired-sample T test there was no significant difference between the ratings for Beat Saber (M = 13.5, SD = 5.7) and Ragnarock (M = 16.1, SD = 5.5), t = 1.9, $p = 0.072$, although there is some evidence for an association that may be worthy of further investigation. That said, both games are single-player and feature no dialogue with non-player characters (NPCs), so social interaction is limited – as is reflected in the overall lower scores on this scale for both titles.

On the individual statement level, there was a difference observed in statement 6 ("I felt like I was in the presence of another person in the virtual environment"), with higher ratings for Ragnarock. Results of a Wilcoxon signed-rank test indicated that there is a significant difference between Beat Saber (M = 2.5, SD = 1.4) and Ragnarock (M = 3.4, SD = 1.2), $z = -2.0904$, $p = 0.0366$. This was expected (see $H_2$), given that Ragnarock had a number of NPCs in the environment with the player, whereas Beat Saber has no social component (either real or artificial). It was perhaps surprising that any participants agreed with these statements for Beat Saber (see Figure 3), although this could have been a result of misunderstanding MPS questions.

These results suggest that the design of Ragnarock may be slightly more effective at creating a sense of social-presence for players, although further research would be needed to confirm this. Despite the lack of statistical significance at the sub-scale level, the data did reveal some interesting patterns and trends that warrant further investigation.

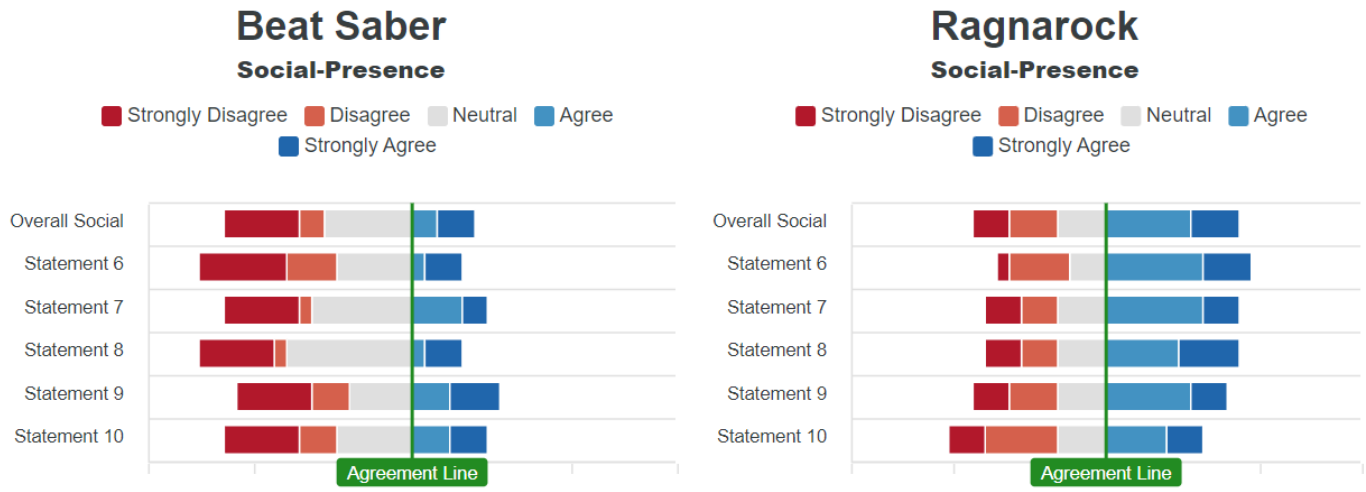


**Figure 3.** Comparison between social presence ratings for Beat Saber and Ragnarock. This shows low scores for social presence in Beat Saber (as expected) and average scores for Ragnarock. Additionally, Ragnarock scored significantly higher in statement 6 ("I felt like I was in the presence of another person in the virtual environment.").

#### 4.1.3. Self Presence

The self-presence subscale data was shown to be normal using Shapiro-Wilk ($W = 0.9552$, $p = 0.4536$), but there were no significant differences for the sub-scale (on a paired-sample T-test), or any of the individual statements within it (on a Wilcoxon signed-rank test) in the MPS. While this may be surprising given $H_3$, it is possible that factors such as the players' individual characteristics or experiences may have played a more important role than the design elements of the two games.

Similar to physical presence, self presence ratings were relatively high for both titles, with a majority of users agreeing or strongly agreeing with the statements (see Figure 4).

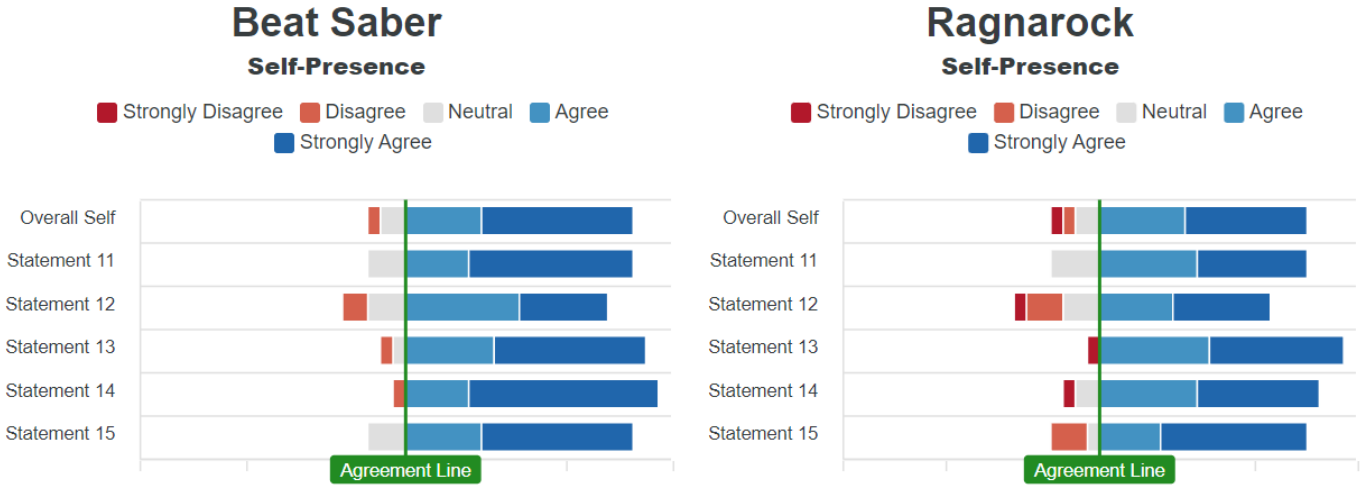


**Figure 4.** Comparison between self presence ratings for Beat Saber and Ragnarock. This shows very high results for self presence in both titles, but no significant differences overall or for any of the statements.

### *4.2. Thematic Analysis*

In order to gain a more in-depth understanding of players' experiences in VR rhythm games, we also conducted a thematic analysis of the open-ended responses. This allowed us to analyse recurring patterns in the data and identify specific design elements which contribute to presence and immersion in VR rhythm games (including how these may vary between different games and players).

We present the findings below for each of our three open-ended questions (your objectives in the game, your frustrations with the game, and the game's UI) separately. We then integrate our analysis over the three questions, suggesting that the responses show users adopt distinct and separate mindsets when interacting with our two games.

#### 4.2.1. Player Objectives

This section focuses on the objectives and goals of players in the VR rhythm games. Through the coding and analysis process, we identified 13 unique codes that occurred 88 times in our data. This led to the development of 6 main themes that captured the objectives of players as they interacted with the games. Table 4 provides an overview of the themes, with frequencies for each game and indicative quotes.

The majority of users made mention of a *Physical Action* as part of their assumed objective for the games. This theme was manifested through the use of active verbs like 'hit', 'cut', and 'slice'. The prevalence of this theme was slightly higher for Beat Saber than for Ragnarock (again supporting $H_1$), and was strongly associated with high physical presence ratings in most cases (see Section 4.1.1). Several users also commented on the additional movement required in Beat Saber to "avoid obstacles in the environment" (U18). This suggests that the sensorimotor activation required to play these games, particularly in Beat Saber, had a significant impact on players' experiences of physical presence and immersion.

The *Coordination* theme was quite evident in the data, with a much higher prevalence in Beat Saber than in Ragnarock. In Beat Saber, coordination was mostly described through the awareness required to cut the blocks in the right spatial direction. Some participants also mentioned the need for timing and using the correct hand. In Ragnarock, there was more focus on visual awareness and the need to match musical note symbols with the correct drum. In both cases, this theme corresponded with high physical presence ratings, indicating that the coordination challenges the games presented influenced players' experiences of physical presence and immersion.

More participants in Beat Saber made specific reference to the *Tool Use* in the game. In Beat Saber, players use virtual swords to slash and cut blocks, while in Ragnarock, players use virtual hammers to hit drums. Of the five users who mentioned 'sabers', they all either agreed or strongly agreed with statement 14 of the MPS ("I felt like my real hand was inside of the virtual environment"). Only one user from Ragnarock discussed tool use, and they also agreed with this statement. These findings suggest that the design of the tools and the way they are integrated into the virtual environment impacts players' experiences of presence: the sabers evoked this particular dimension of presence more effectively than the hammers.

Perhaps unsurprisingly, *Musicality* was the most prominent theme in the data and was characterised by participants' focus on the music and the role it played in their experiences. More people mentioned the music specifically for Ragnarock than Beat Saber, particularly in relation to staying on beat. This may have arisen from the former's requirement that the user act precisely on the beat, while in the latter the user's "saber" must only be in the right place at the right time—it can arrive there beforehand without penalty. In both games, some participants alluded to the musical aspects of the games through the use of more general words like 'in time', rather than explicitly mentioning the beat.

Relatively few people talked about *Gamification* in relation to the purpose of the VR rhythm games. Those who did tended to focus on progress and ability, such as how far they could get in a song and their accuracy and scores. There was a similar prevalence of these themes in both Beat Saber and Ragnarock, with only one user overlapping between groups. Additionally, only two users used the word "perfectly" in their responses for Ragnarock, with none of the other users referencing flawless performance when discussing their objectives.

**Table 4.** Frequency of themes per game relating to users' objectives, with illustrative quotes.

| Theme | Beat Saber Frequency | Ragnarock Frequency | Constituent Codes and Indicative Quotes |
| --- | --- | --- | --- |
| *Physical Actions* | 16 | 10 | *Codes:*<br>• Active verb describing physical activity (e.g., hit, cut)<br>• Additional physical movement<br>*Quotes:*<br>• "Trying to hit the blocks" (U7—Beat Saber)<br>• "Trying to actually hit the drums" (U6—Ragnarock) |
| *Coordination* | 12 | 5 | *Codes:*<br>• Spatial awareness of approaching objects<br>• Paying attention to visual aspects<br>• Coordinating movement between hands/controllers<br>• Specific mention of the required direction<br>*Quotes:*<br>• "To slice the boxes on time in the direction with the right hand" (U3—Beat Saber)<br>• "to move my hands holding controllers in time with virtual drumming cues"(U18—Ragnarock) |
| *Tool Use* | 5 | 1 | *Codes:*<br>• Use of tools to achieve goals<br>*Quotes:*<br>• "Using the lightsabers. . . to slash the boxes in a certain way" (U10—Beat Saber)<br>• "hammer hands to hit the drum" (U4—Ragnarock) |
| *Musicality* | 8 | 19 | *Codes:*<br>• General musical context<br>• Timing alluding to syncing with the beat<br>• Referencing the rhythm/beat of the music<br>*Quotes:*<br>• "Trying to hit the boxes to the beat of the music" (U1—Beat Saber)<br>• "To drum to the beat of the song and follow the visuals on which drum to hit at what time" (U10—Ragnarock) |
| *Gamification* | 5 | 6 | *Codes:*<br>• Striving for maximum performance<br>• Placing emphasis on the outcome of the game<br>*Quotes:*<br>• "Hit the notes with sabers aiming for a high score, rank and accuracy" (U11—Beat Saber)<br>• "To move the ship from one end to the other by drumming"(U17—Ragnarock) |
| *Abstraction* | 1 | 1 | *Codes:*<br>• Abstract representation of narrative identity<br>*Quotes:*<br>• "To become a jedi" (U8—Beat Saber)<br>• "To become a drumming master" (U15—Ragnarock) |

One of the more unique themes in the data was *Abstraction*, where participants referred to a conceptualisation of their potential role or identity in the VR rhythm games. One participant in Beat Saber referred to the goal of "becoming a Jedi" (U8), while another participant in Ragnarock referred to their aim of "becoming a drumming master" (U15). Interestingly, both of these users strongly agreed with all of the self-presence statements in the MPS. While this theme was not as prevalent as others, it provides some insight into how players may construct meaning and narrative in the virtual environments of VR rhythm games. It's possible this framing may influence their sense of self-presence and overall immersion.

#### 4.2.2. Player Frustrations

This section reports on the frustrations and issues users' experienced while playing. The analysis of these responses revealed a set of themes that differed between the two games, with none of the overlap observed in the analysis of player objectives (see Table 5). These themes provide insight into the factors that can disrupt presence and immersion in VR rhythm games, highlighting the need for careful design to ensure that players have a positive and engaging experience.

In Beat Saber, only 43% of users ($n$ = 9) reported frustrations, with 57% ($n$ = 12) for Ragnarock. As a result, there is less frequency of the themes appearing in the data. Overall there were 8 codes applied 29 times, which were grouped into 5 themes.

One theme that emerged from the analysis of participants' responses was the *Skill* required to play Beat Saber. Some participants reported frustration with the game due to its difficulty and the need for coordination to successfully hit the blocks in the right direction. One participant mentioned that "there were times where I would miss or incorrectly cut a block but I didn't think I did" (U2). These experiences suggest that Beat Saber can be challenging for some players, and may require a higher level of skill and coordination than other VR rhythm games. This could be a factor that impacts players' feelings of presence and immersion, as difficulty and frustration can potentially disrupt the flow of the game and the player's sense of being fully immersed.

Another theme for Beat Saber was centred around not fully understanding the *Game Mechanics*. In particular, four participants mentioned the required direction for hitting the blocks and the need to physically avoid large boxes in the virtual environment. Despite these challenges, most participants with this frustration reported that they 'realised' the correct mechanics of the game. One participant even commented "they were pretty intuitive though, I was able to learn them" (U15). This indicates that players are able to adapt and learn the correct strategies and techniques over time, particularly if the interactions are more natural and instinctive. This also did not seem to affect those four users' sense of presence, with mean ratings of 24.75 for the physical presence sub-scale and 23.75 for the self presence sub-scale.

In Ragnarock, the most prominent theme focused on the *Spatial Limits* users experienced. This theme characterised the difficulty of users positioning themselves in a way that would allow them to reach all of the drums in the game. Some participants reported that some of the drums were outside of their field of view, which made it difficult to hit them accurately. Three of those participants specifically mentioned instances where they thought they had hit the drum, but the game did not register the hit, which led to frustration. These experiences suggest that the spatial limitations of Ragnarock can be challenging for some players, and may impact their ability to fully engage with the game and experience a sense of presence and immersion.

**Table 5.** Frequency of themes per game relating to users' frustrations, with illustrative quotes.

| Theme | Beat Saber Frequency | Ragnarock Frequency | Constituent Codes and Indicative Quotes |
|---|---|---|---|
| *Skill* | 4 | 0 | *Codes:*<br>• Lack of skill/coordination<br>*Quotes:*<br>• "Wasn't coordinated enough to get the movements right" (U13—BeatSaber) |
| *Game Mechanics* | 4 | 0 | *Codes:*<br>• Unfamiliar with the game mechanics<br>*Quotes:*<br>• "I kept missing the boxes until I realised I need to hit them in a certain direction" (U1—BeatSaber) |
| *Spatial Limits* | 0 | 8 | *Codes:*<br>• Impossible to see all the drums at the same time<br>• Spatial limitation reaching the drums<br>*Quotes:*<br>• "Sometimes when I try to hit the drums that were further away from me, the game wouldn't recognise it" (U18—Ragnarock) |
| *Rhythmic Timing* | 0 | 6 | *Codes:*<br>• Difficulty timing actions with beat<br>*Quotes:*<br>• "I felt like I was in time with the music, but unfortunately wasn't." (U17—Ragnarock) |
| *Appropriate Feedback* | 0 | 3 | *Codes:*<br>• Unrealistic force feedback<br>• Not enough distinction in haptic feedback<br>• Incorrect diegetic response<br>*Quotes:*<br>• "I don't think there was enough distinction between haptic feedback for when the drum was hit as opposed to when it wasn't." (U2—Ragnarock) |

Another theme that emerged from the analysis was related to *Rhythmic Timing* in Ragnarock. Approximately half of the comments made mention of frustration arising from the game's need for precise timing. This frustration was due to a range of factors, including the general challenge of timing in a rhythm game, as well as the difficulties related to the spatial limitations of the game (as discussed above). Some participants reported a disconnect between the beat of the music and the corresponding notes that they were supposed to hit, leading to difficulty in maintaining the correct rhythm.

The last theme for Ragnarock was the issue of *Appropriate Feedback*. Three participants specifically mentioned their experiences with the feedback mechanisms in the game, with each expressing a different perspective. One participant was frustrated by the lack of distinction between haptic feedback when the drum was hit, making it difficult to understand when they had successfully hit a drum. Another participant found the lack of physical feedback force (as a real drum would provide) to be frustrating, as it made it harder to "correct for missed/wrong notes" (U18). This was not mentioned as a frustration in Beat Saber, possibly because the laser swords cut through objects, where little resistance is expected. The third participant did not think that the diegetic feedback of the Viking crew was legitimately connected to their progress in the game, which may have reduced engagement with the narrative of the experience. These points suggest that the feedback mechanisms in Ragnarock can be problematic for some players, and may impact their ability to feel a sense of presence, for all three of Lee's factors (physical, social and self).

#### 4.2.3. Player Experiences with the Game UIs

This section presents the findings from the analysis of participants' responses related to the user interfaces and experiences of the two VR rhythm games. Although the question was originally framed around the user interfaces of the two games, some participants discussed their overall experience of playing the games. We included these broader experiences in our analysis, as they provide understanding of some of the factors that can impact players' perceptions of presence. In total, there were 29 applications of 7 codes, culminating in 4 themes (see Table 6).

**Table 6.** Frequency of themes per game relating to user interfaces and experience, with illustrative quotes.

| Theme | Beat Saber Frequency | Ragnarock Frequency | Constituent Codes and Indicative Quotes |
| --- | --- | --- | --- |
| *Intuitive Interfaces* | 9 | 8 | *Codes:*<br>• Easy, simple and intuitive interface<br>• Additional physical movement<br>*Quotes:*<br>• "Very easy to use and understand" (U5—Beat Saber)<br>• "The interface was very intuitive" (U17—Ragnarock) |
| *Aesthetics* | 3 | 2 | *Codes:*<br>• Matching visual look for the atmosphere<br>• Music style contributed to the overall immersion<br>*Quotes:*<br>• "The music helped me be more immersed into the digital looking environment" (U10—Beat Saber)<br>• "matches the aesthetic and theme of the world" (U17—Ragnarock) |
| *Realism* | 3 | 1 | *Codes:*<br>• Realism from motion/movement<br>• Immersion in an abstract environment<br>*Quotes:*<br>• "The cubes and that came towards me were really realistic" (U3—Beat Saber)<br>• "the drums also following exactly my movements felt super" (U10—Ragnarock) |
| *Affordances* | 2 | 1 | *Codes:*<br>• Positioning of self and objects provided contextual information<br>• Affordances of controls<br>*Quotes:*<br>• "the lightsabers followed the remote movements perfectly which helped me make precise movements just like in the real world" (U10—Beat Saber)<br>• "the drums were right in front of me and were obvious that I had to hit them." (U3—Ragnarock) |

One theme that was generated in the analysis depicted the *Intuitive Interfaces* for both Beat Saber and Ragnarock. A similar number of comments were made about the user interfaces for both games, saying they were 'simple to understand' and 'easy to use'. The findings from this analysis suggest that both Beat Saber and Ragnarock have intuitive interfaces that help create a seamless experience. It's possible this allows players to immerse themselves further in the virtual environment and fully engage with the game, rather than being distracted by confusing or complex interfaces.

In both Beat Saber and Ragnarock, participants mentioned how the *Aesthetics* of the game environments, objects and interfaces contributed to their overall experience of the game. For example, some participants noted that the 'digital looking' environment of Beat Saber, with its 'level of abstraction from reality', added to the immersive quality of the game.

Similarly, a participant in Ragnarock mentioned that they "liked the wooden aesthetic" of the game. These comments suggest that the aesthetic design of VR rhythm games can be an important factor in enhancing players' experiences of presence and immersion. This was not limited to visual aspects, but also included the music itself which was evidently appropriate for the themes of the respective games.

Another theme was the role of *Realism* in enhancing players' experiences of presence and immersion in VR rhythm games. Two participants in Beat Saber mentioned how "real" or "realistic" the boxes flying towards them felt. This was focused around the motion of game objects and not the visual realism of the experience or the fidelity of the visual rendering.

A notable finding from the analysis was the role of *Affordances* in supporting players' experiences of presence and immersion. In the case of Beat Saber, a participant mentioned how the design of the virtual laser swords, which were synchronised with the movement of the VR controllers, helped them to 'make precise movements' in the game which felt realistic. A participant in Ragnarok mentioned how their position in the virtual environment gave them the perception they were the 'captain of the ship'. These examples demonstrate how the design of affordances could potentially influence physical or self presence.

### *4.3. Overall*

One way to understand the divergent themes identified across the two games is through the lens of player mentality. We see four distinct (although co-occurring) mentalities as giving rise to the themes we observed: Action, Game, Narrative, and Musical (see Figure 5). We use these mentalities as higher-level organising themes [36] in our thematic map [7], positing them as key constructs which influenced players' experiences of presence and immersion. The specifics of the different mentalities are discussed in Section 5.

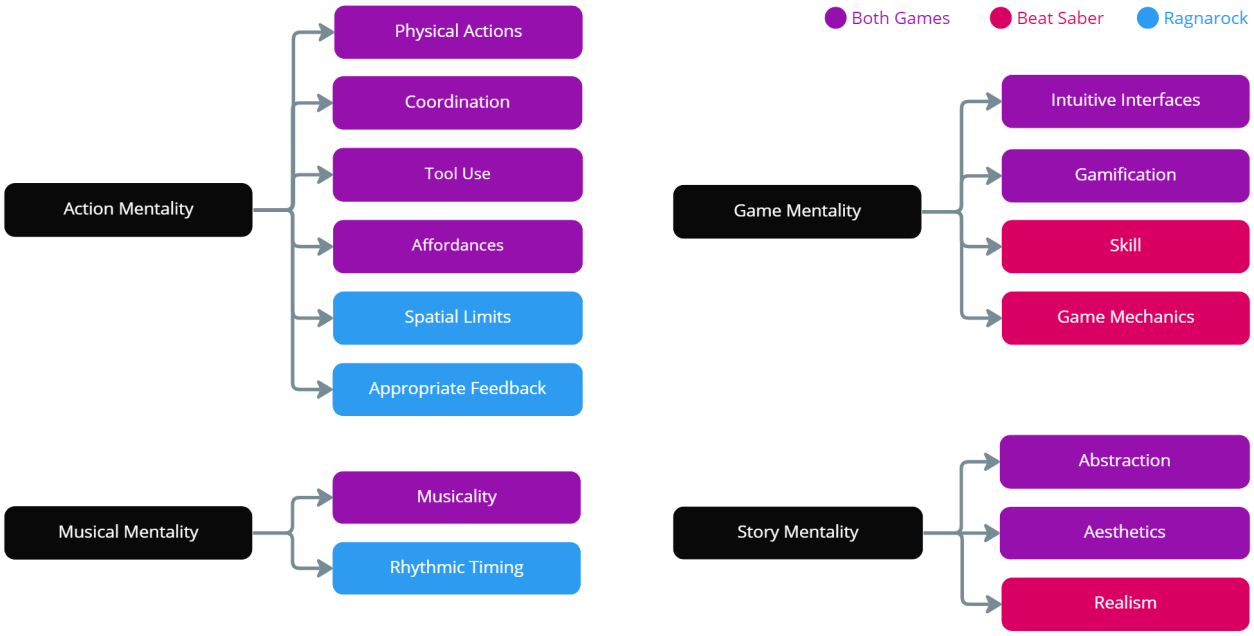


**Figure 5.** A thematic map indicating the hierarchy between player mentalities and themes from our thematic analysis comparing Beat Saber and Ragnarock. Four mentalities were identified: Action (focus on physical engagement and movement), Game (focus on ability and level completion), Musical (focus on rhythm and beat) and Narrative (focus on the fictional elements of the world).

## 5. Discussion

The purpose of this study was to understand how users' experiences impact their sensations of presence and immersion in the context of VR rhythm games. Analysing both our qualitative and quantitative results, we found evidence to support very different player

mentalities being adopted when engaging with these games. Drawing on theory, we map how these mentalities contribute to immersion (using [11]) by leveraging various factors of presence (see [6]), in Figure 6. While these relationships between mentalities, presence and immersion arose in the context of the games Beatsaber and Ragnarock, we contend that they are likely generalisable to at least other VR rhythm games, and may provide insight to the designers of rhythm games in other platforms where immersion is a significant factor in the experience.

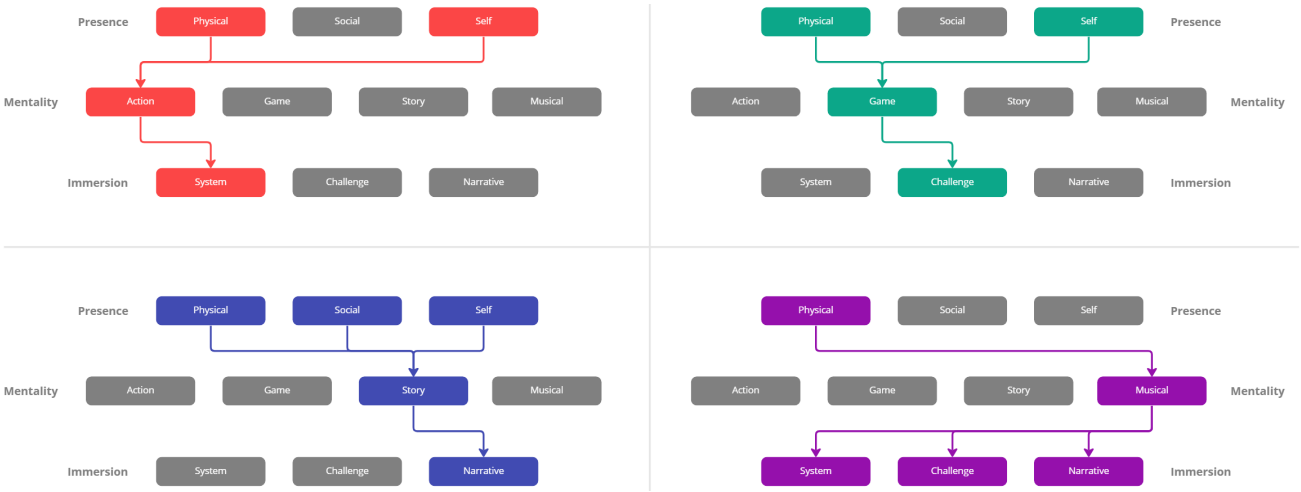


**Figure 6.** Mappings between presence (after Lee, 2004) and immersion (after Nilsson et al., 2016) for each of the four mentalities identified in our analysis of Beat Saber and Ragnarock: Action, Game, Story, Musical.

We observed four main mentalities among users, and noted that each had a different mediating effect on how that user felt present and experienced immersion. With the *Action Mentality*, users prioritise physical engagement and coordination with in-game tools, leading to a sense of embodied self presence, which enhances system immersion by directing the player's attention to their physical agency in the virtual environment. The *Game Mentality* is adopted by players who aim to achieve success through accuracy and level completion, leveraging physical and self presence to increase challenge-based immersion. The *Story Mentality* classifies users who use the fictional elements of the game to shape their interpretation, combining all three dimensions of presence to support a sense of narrative immersion. The *Musical Mentality* denotes a concentration on general musicality, as well as specific bodily movements in response to rhythm, which connects physical presence with all three components of immersion (system, narrative, and challenge-based).

In the remainder of this section we describe in detail these mentalities and how they mediate the experience of presence and immersion. These mentalities can be experienced exclusively or in combination, and can vary throughout the game experience.

It is important to note that our analysis was not a comparison of which game is better, but rather an investigation of the relative strengths of each successful title. To that end, we focus on the positive contributions outlined in our thematic analysis, putting aside issues like usability concerns. In this discussion, we also propose several suggestions for how design elements can encourage the adoption of these mentalities, in order to leverage presence for different types of immersion.

### *5.1. Action Mentality*

The *Action Mentality*, characterised by physical engagement and coordination with in-game tools, influences players' experiences of system immersion in VR rhythm games. This leverages the factor of physical presence for the environment and involves self presence and a sense of embodiment. This focus on acting as a body in an environment leads to System immersion, as the user's mindset foregrounds their "physical" agency in the virtual world.

Physical engagement was often closely integrated with the task requirements of the game, such as cutting the block in the right direction in Beat Saber or hitting the drum at the right time in Ragnarock. This may help explain why the coordination theme was more prevalent in Beat Saber, which requires a higher degree of temporally precise sensorimotor activation compared to Ragnarock. A tight coupling of physical action and user objectives was evident in the qualitative data, corresponding with relatively high ratings for physical and self presence in both games. To help maximise the *Action Mentality*, designers should place the player's body at the centre of the experience, within a clear spatiotemporal context for their actions.

In Beat Saber, all of the game objects are centrally located within the users' field-of-view and are designed in such a way that they move towards the player making them easy to reach and interact with. In contrast, Ragnarock has some objects that are key to the interaction located outside of the player's peripheral vision, which evidently led to frustration. Even though the technology is capable of tracking the controller beyond the field-of-view, it can still be difficult for users to coordinate their actions and they consequently blame the system rather than their own abilities. This highlights the importance of designing experiences with appropriate spatial relationships between the player's body and the objects in the virtual environment. Failing to do so could break the sense of physical presence, creating a disconnect with the virtual environment and impacting system immersion.

In both games, the tools that players used to interact with the world seemed to become what Heidegger referred to as 'ready to hand' [37], where the tools extended the users' bodies and cognition. This was indicated in the qualitative data with more of a focus on what the tool achieved (i.e., cutting/hitting) rather than the tool itself (i.e., saber/hammer). One participant in Ragnarock even mentioned having 'hammer hands', conceptually connecting their body with the tool and indicating an experience of extended cognition. The quantitative data reinforced this, given the high ratings for statements 13 and 14 of the MPS questionnaire regarding the involvement of arms and hands in the experience (see Section 4.1.3 and the *Tool Use* theme in Section 4.2.1).

The tools used in VR games are often not thought about by players until the cognitive connection is broken, such as when a player misses a beat or makes a mistake. Our findings suggested that this disconnection can also be caused by a lack of appropriate feedback from the tool. At this point it becomes 'present to hand' in Heideggerian terminology—consciously apparent as broken—which can lead to frustration and impact the players' experience of presence and/or immersion. Tools in VR rhythm games should support and perhaps even enhance the *Action Mentality* of players, allowing them to achieve their objectives while minimising risk of accidental error.

The increased emphasis on the physical actions in Beat Saber explains the significantly higher ratings for that subscale of the MPS (see Section 4.1.1). This suggests that more players may have adopted the *Action Mentality* when playing the game, compared to Ragnarock. In Ragnarock, player frustrations revolved around physical concerns (e.g., spatial limitations and feedback). These issues may have detracted from the *Action Mentality*, consequently limiting physical presence and reducing system immersion. The frustrations in Beat Saber were related to skill and game mechanics, which is discussed further below.

### *5.2. Game Mentality*

The Game Mentality is characterised by players who constructed their experience with the game through a focus on the rules and objectives, as well as on achieving success through the accumulation of points or other game-related metrics. For Beat Saber and Ragnarock, this mentality also leverages physical and self presence, harnessing them to increase challenge-based rather than system immersion.

One aspect of this mentality was a willingness to attempt to succeed at the game, indicated by the use of language such as 'try/trying' and 'ability'. Although only mentioned by a minority of players, this suggests those users understand that the game is a challenge they are supposed to complete (with very few expecting to perform perfectly). Even fewer

users specifically referenced game concepts like 'scores' or 'levels' in their descriptions of their objectives. This may indicate that for many players, the game structure and objective may not be as important as other factors, such as the narrative, the music, or the overall atmosphere.This may be more pronounced among new players in particular, as they are learning how to interact with the virtual environment. Players past that initial adaptation phase, however, may adopt the Game Mentality, placing more focus on achieving high scores and other game-related objectives.

The level of skill required to play the games effectively appeared to be an obstacle for some players, who become frustrated by the challenge of timed movements and other typical rhythm game mechanics. In Beat Saber, this quickly led to a negative experience, perhaps due to difficult and unfamiliar "saber" movements, compared to the drumming motions in Ragnarock. This was likely exacerbated by a lack of understanding of all the gameplay elements. Beyond these frustrations, the Game Mentality appears to draw on physical and self presence to link skill with challenge-based immersion. This can lead to both positive and negative outcomes, depending on whether the player perceives themselves as progressing. It is within this mindset that concepts like flow (see [38,39]) and adaptive difficulty (see [40,41]) may be understood as moderating immersion, although further research would be required to explore that.

For VR rhythm games, the challenge is largely physical, as players must coordinate their bodily interactions with the virtual environment with the music. This interaction involves some sense of self presence, as players are using a virtual extension of their own body to play the game. The feelings of presence that arise from this interaction can be combined and harnessed to create a sense of challenge-based immersion. Within the games that were part of this study, there were no social aspects explored in the games that contributed to the challenge. This suggests that the challenge in these games is primarily individual, with players competing against their own skills and abilities rather than against others. However, this is not necessarily the case for all VR rhythm games, and certainly not the case for games in general: collaborative elements of challenge are commonplace and effective, just beyond the scope of our analysis.

### *5.3. Story Mentality*

Users who adopted a *Story Mentality* were invested in the fictional elements, experiencing the games at a level beyond just the physical actions or game mechanics. For Ragnarock at least, this linked all three dimensions of Lee's model of presence [6], contributing to the overall sense of narrative immersion. Nilsson's narrative immersion combines "imaginative immersion" from [27] and "fictional immersion" from [28] to expand beyond traditional notions of plot. Narrative immersion encompasses an "active creation of belief" [42] in the diegetic space, including a construction of a self-identity and attribution of motives to characters within the world. In this mentality, the story is the narrative players create for themselves about the fictional environment, not an explicit plot (of which there is little in Ragnarock and none in Beat Saber).

While the two games had substantial aesthetic differences, the comments suggested that each game was able to effectively convey a sense of its fictional environment. This was discussed not just about the overall look of the virtual world itself, but also the interfaces and the way they supported the atmosphere. A naive reading of the quantitative results' higher rating for Beat Saber in response to statement 1 of the MPS (see Section 4.1.1) regarding a feeling of "realism" is that it came from graphics and rendering quality. However, that was not how users discussed realism in the qualitative data. Rather, the two people who commented that Beat Saber was "realistic" appeared to reference the perceptual realism of the cubes flying at them. This notion of realism connects with Lee's definition of physical presence: "objects are experienced as actual physical objects in either sensory or nonsensory ways" [6]. The blocks were not "graphically" realistic, they were "perceptually" realistic—they flew directly at you in a manner that was entirely unignorable. The *Story*

*Mentality* should leverage physical presence to maintain narrative immersion by creating a consistent diegetic space, upholding the place illusion [8].

Despite the lack of social challenge embedded within the games (at least within the game modes for our study), there were some reported feelings of social presence. This was particularly the case for Ragnarock (see Section 4.1.2) where users described feeling as though they were in the presence of other people, referring to the 'Vikings' on board the ship in the qualitative data. Even though there was little direct social interaction with these characters, their existence evidently added to the atmosphere of the experience. This was primarily related to the identity that users constructed and assigned to themselves, combining social presence with self-presence. However, the presence of social actors could also be a detractor for immersion if there is not appropriate feedback. While this was not particularly prominent in the data, it is still a useful consideration when leveraging social presence for narrative immersion in VR rhythm games.

It appears that users' sense of self presence is also leveraged by their *Story Mentality*, as seen in the perspective they take when thinking about their objectives in the game. This is evident in the way that players use abstractions and cultural references to shape their fictional interpretation of the virtual experience. For example, a user playing Beat Saber mentioned "becoming a jedi" as part of their objective. This supports the definition of narrative immersion discussed above, as this concept was never explicitly used in the game, but rather formed in the mentality of the user which then shaped their experience. Designers of VR rhythm games should consider how to utilise this aspect for immersion, understanding the narrative context they may be placing the users in.

### *5.4. Musical Mentality*

The Musical Mentality revolved around a focus on both general musicality (i.e., playing a song) and specific rhythmic timing (i.e., staying on beat). In a sense, this mentality is unique in that it connects to all three of the kinds of immersion, due to music's ability to occupy the mind sensorily (system immersion), emotionally (narrative immersion), and—at least when playing an instrument or a rhythm game—kinaesthetically (challenge-based immersion).

This mentality was more prevalent in the game Ragnarock, which makes sense given the relative para-authenticity of the game's drumming mechanic. While the connection between the physical activity of hitting the drum on the beat and making progress through the song is stronger in this game, a sense of self presence through the required motor output was evident in Beat Saber as well. This combination of music and motion serves to enhance the challenge immersion for both games.

Music is a core component of system immersion in these games. In terms of atmosphere, music provides its own aesthetic, which is different yet evidently appropriate for both games. The use of spatial audio and how that impacts immersion could be an area for further study in the context of VR rhythm games.

In the context of VR rhythm games, music can influence the creation of a story to contribute to narrative immersion. Through affective and cognitive means, music provides an imaginative mythos for the fictional world, without necessarily being realistic or historically accurate. Vikings, at least the non-time-travelling kind, would be unlikely to have listened to Celtic metal. However, the perceived aesthetic link between the two by the (modern) player effectively engages the Story Mentality and enhances the immersive experience.

### *5.5. Design Affordances*

Through our study we have identified different mentalities users can adopt when playing rhythm games, which mediate presence and help construct immersion. Importantly, these mentalities are not directly causal with respect to presence and immersion, meaning that they do not have a one-to-one relationship. Rather, they are complex psychological phenomena that are influenced by a variety of factors, including the design features of the game and the individual characteristics of the player. Our study observed these mentalities

in the same VR system, using similar rhythm games, and allowed us to observe and compare their impacts on presence and immersion. What is clear is that decisions made by designers are likely to lead to virtual environments that afford different mentalities to different degrees. Game designers who want their VR games to be immersive and/or to evoke feelings of presence may find it more accessible to instead design for one or more mentalities. Our analysis suggests that, at least in the context of VR rhythm games, but we suspect applicable more broadly, these mentalities mediate between certain kinds of presence and immersion, allowing designers to target those effects indirectly.

The action, game and story mentalities are likely more universal than just VR rhythm games, although we have not validated that expectation. Further research could explore that generalisability, to better understand the ways in which these mentalities influence presence and immersion in a wide range of interactive media. The *Musical Mentality* appears to have a connection to high levels of immersion in all 3 axes of the taxonomy from [11] (see Figure 7). This may be part of the reason for the popularity of this genre of games, but it's less clear that this effect will generalise beyond rhythm games. While music is ubiquitous in games and playable media of all types, further research would be needed to identify the degree to which the *Musical Mentality* is something players would adopt in games where musicality is not core to gameplay. Below, we describe how these mentalities can be encouraged in players, providing examples for thinking about and applying the model when designing rhythm games.

A design which affords the *Action Mentality* could lead to more physical and self presence, in turn contributing to system immersion. To accomplish this, games should implement a higher degree of movement and sensorimotor activation, as seen in Beat Saber's high physical presence scores (see Section 4.1.1). In a VR context, games should also consider placing the user at the centre of the experience, minimising locomotion and increasing perceptual realism by creating optical flow through object movement towards the player. Lastly, this mentality can be encouraged by using in-game tools which work around the limitations of tactile feedback in VR. For example, players expect that the laser swords in Beat Saber slice through the blocks with no resistance, while the drums in Ragnarock would be expected to provide some force feedback (the absence of which led to a disconnect and impacted system immersion). Another example would be shooter-based rhythm games like Pistol Whip, where the feedback of the guns can be somewhat simulated using the haptic rumble in the VR controllers, but a lack of physical resistance from target impacts is, like with the laser swords, not an issue. Alternatively, the need for additional tools can be negated, by using the player's body for control, such as in the game OnShape.

Encouraging the *Game Mentality* can create more physical and self presence, which will in turn mediate players' challenge-based immersion. Design recommendations here will largely echo those of any introductory games design course (clear and learnable mechanics, tutorials or other opportunities to acquire mechanical skill, etc), with the added dimension of the body. While this may seem obvious, it was evident in our data that this limited some users from adopting the *Game Mentality*. These types of games should also attempt to balance challenge level with potential skill of the players. This can occur not just through selectable difficulty levels (a staple of the rhythm game genre), but potentially through dynamic difficulty adjustment mechanics [43], an area which likely deserves specific attention in a VR context.

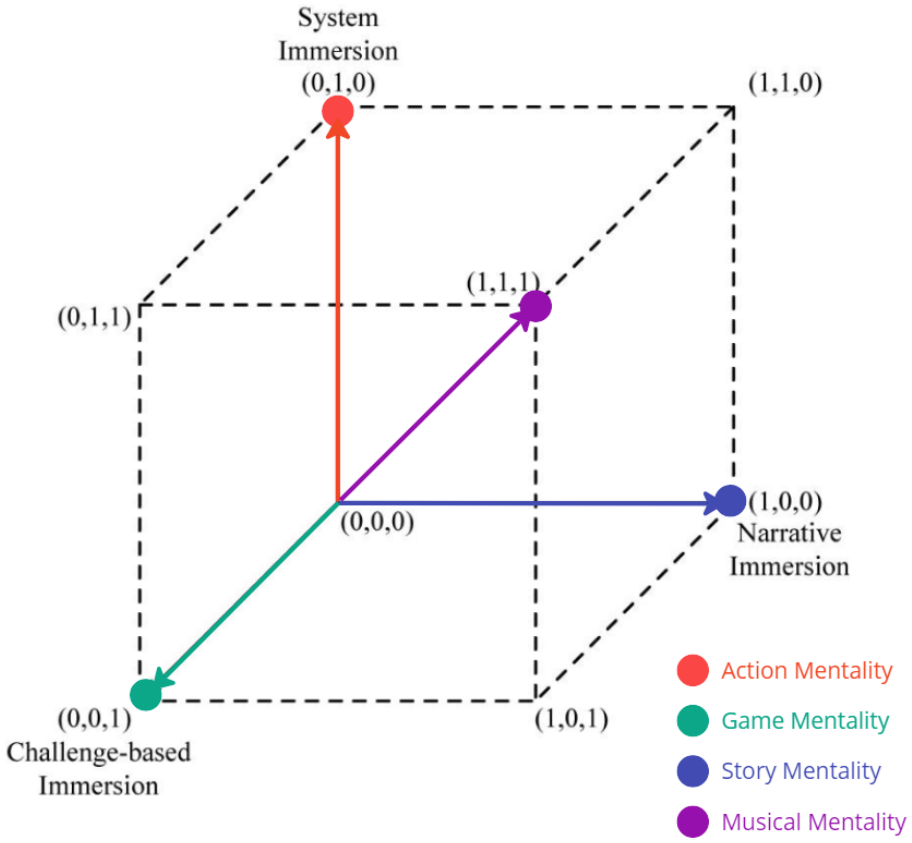


**Figure 7.** Translation of the mentalities identified in our analysis of Beat Saber and Ragnarock to the 3-axis taxonomy of immersion from Nilsson (2016). The Action, Game and Story mentalities map directly to System, Challenge-based and Narrative immersion respectively. The Musical mentality in a rhythm game can be considered immersive across all 3 categories.

By encouraging *Story Mentality*, designers can enhance all three of physical, social and self presence, and in doing so contribute to narrative immersion. Note again that "narrative" in this context does not only refer to plot and character development, but more broadly to aesthetics and that sense of shared imagination. To do this, designers should focus on crafting consistent diegetic spaces which don't only consider visual aesthetics, but also coherence of physical properties, player identity, additional NPCs and overall atmosphere. Our quantitative data showed a higher level of social presence for Ragnarock (see Section 4.1.2), although this could still be improved through clearer feedback from the interaction. Otherwise, both games had appropriate styles for their contexts, which were embedded in the visuals and interfaces, leading to a high overall sense of physical presence.

When rhythm games are at their best, they invite players into a "jam session"-like state, creating and experiencing music both viscerally and imaginatively. This is the *Musical Mentality*, which creates physical presence contributing to system, challenge-based and narrative immersion. One approach to enhancing this is to select music to enhance the atmosphere of the world for greater narrative immersion. Both Beat Saber and Ragnarock achieve this, using specific genres to support their respective themes. The Guitar Hero franchise famously leveraged this effectively, drawing on the motif of "rock" to bolster the fictional environment. The musical content should also be designed respecting the affordances of the inputs, whether they are para-authentic instruments or more artificial abstractions. Ragnarock capitalised on this with hammering on the drums, which may be why the prevalence of the Musicality theme was higher there (see Section 4.2.1). In contrast, Beat Saber utilises the more continuous swinging motions synchronised with the music to create dance-like interactions, which explains the focus on Physical Actions and Coordination (see Section 4.2.1).

## 6. Conclusions

We have explored, by triangulating between both qualitative and quantitative data, how two popular VR rhythm games (Beat Saber and Ragnarock) harness presence for engaging and immersive experiences. Based on this data we have constructed a model for how designers can leverage these affordances to create more compelling virtual worlds: by targeting particular user mentalities that mediate between presence and immersion. Our mixed-methods approach—combining quantitative data collected with the MPS and qualitative data gathered through open-ended questions—allowed us to analyse feelings of presence and immersion in rich detail across these two games. We discovered that players' experiences within the VR rhythm games were mediated by four mentalities: action, game, story and musical. We found that certain design features of the game encouraged or discouraged the adoption of these mentalities, i.e., different game designs afforded different mentalities. We see this as having important implications for game designers looking to enhance player immersion.

The *Action Mentality* focuses on the physicality of the game experience—which is pronounced in a VR context—and was particularly evident in Beat Saber, which had significantly higher levels of physical presence. This physicality, expressed through embodied co-ordination and associated feelings of self presence, enhances system immersion, as a kind of technology-mediated coupling of perception and action. The *Game Mentality*, which foregrounds the games' mechanics and reward system, was comparatively less pronounced than the action one in both games. In our context, the game mentality leverages physical and self presence towards the task of acquiring and demonstrating game skill, which contributes to challenge-based immersion. Perhaps due to our sample of players being relative novices at these games, this was not as significant to the majority of them. The *Story Mentality* characterises users who are invested in the fiction of the virtual world and associated game elements, supporting a sense of narrative immersion. This was evident both quantitatively (in high physical and self presence ratings for both games), and qualitatively (through how users discussed abstractions and aesthetics). For Ragnarock specifically, the higher degree of social presence also impacted the overall experience of narrative. The *Musical Mentality* facilitated all three modes of immersion (system, challenge-based, narrative), grounded entirely in physical presence. This mentality integrates sensory input, emotional response and physical activation, demonstrating the unique immersive properties of VR rhythm games.

Our study provides insights into how VR rhythm games can leverage presence and construct immersion to create engaging experiences through different mentalities. The four mentalities we observed in our users characterise how players of VR rhythm games construct their own experiences, and may also provide more accessible goals for future game designers to target when compared to more abstract notions of presence and/or immersion. We proposed several considerations for how to best encourage these mentalities through design affordances. These insights can be applied by game designers to optimise the design of VR rhythm games and possibly other interactive media.

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